



The GÉANT Network: Infra to the Next Level

SIG-NGN Prague – 20th of April 2023

Bram Peeters
CNOO GÉANT

Long-term Backbone Traffic Growth

(on GÉANT network largely driven by scientific instruments)

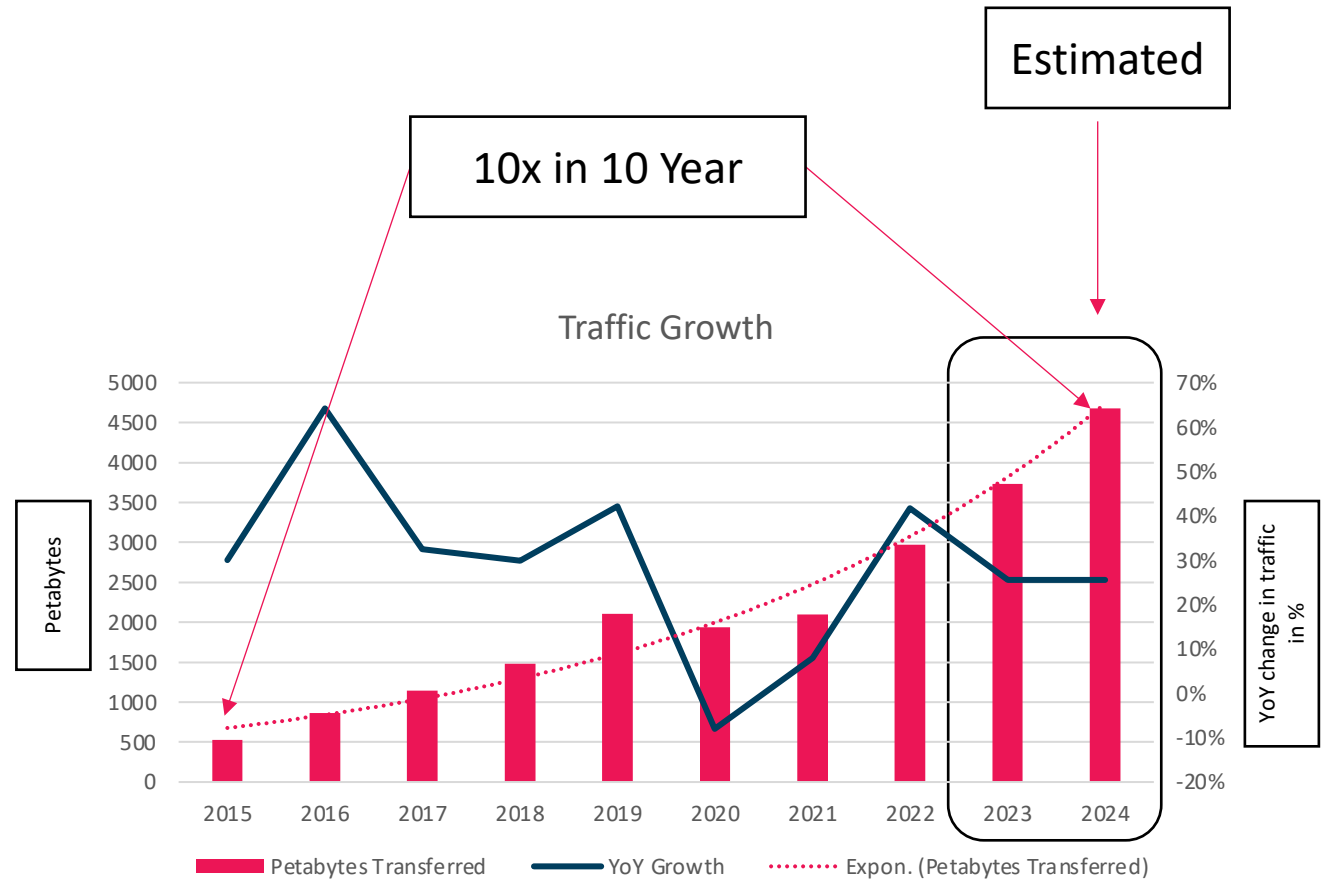
- **Total: 2010 –2022:** growth of over 30% YoY
- **2015–2019:** Traffic growth of 40% YoY
- **2015–2022:** Traffic growth of 27% YoY

Total Backbone Trunk Capacity

February 2019 **2.7 Tbps**

Dec 2022 **9.4 Tbps**

In 2032... **94 Tbps?**



GEANT and the “grand plan” – what is happening?

- **Investing in infrastructure:**
 - **Control**
 - Technology and services => ability to deliver all capacity required, in an appropriate way
 - Financial => sustainable, and affordable
 - **Digital Divide** – research and education anywhere in/from/with Europe
- **Through several projects that provide investment options:**
 - **GN4-3N:** Fiber and Spectrum Infra (2019-2023)
 - **EAP:** Eastern Access Partnership – spectrum? (2015-2025)
 - **GN5-1/2:** Renewal of the Router Layer: 400G, 800G and beyond (2023-2024)
 - **GN5-ic1:** Global Connectivity (2022-2025)
- **All of this as collaborative as appropriate (possible/sensible/beneficial)**

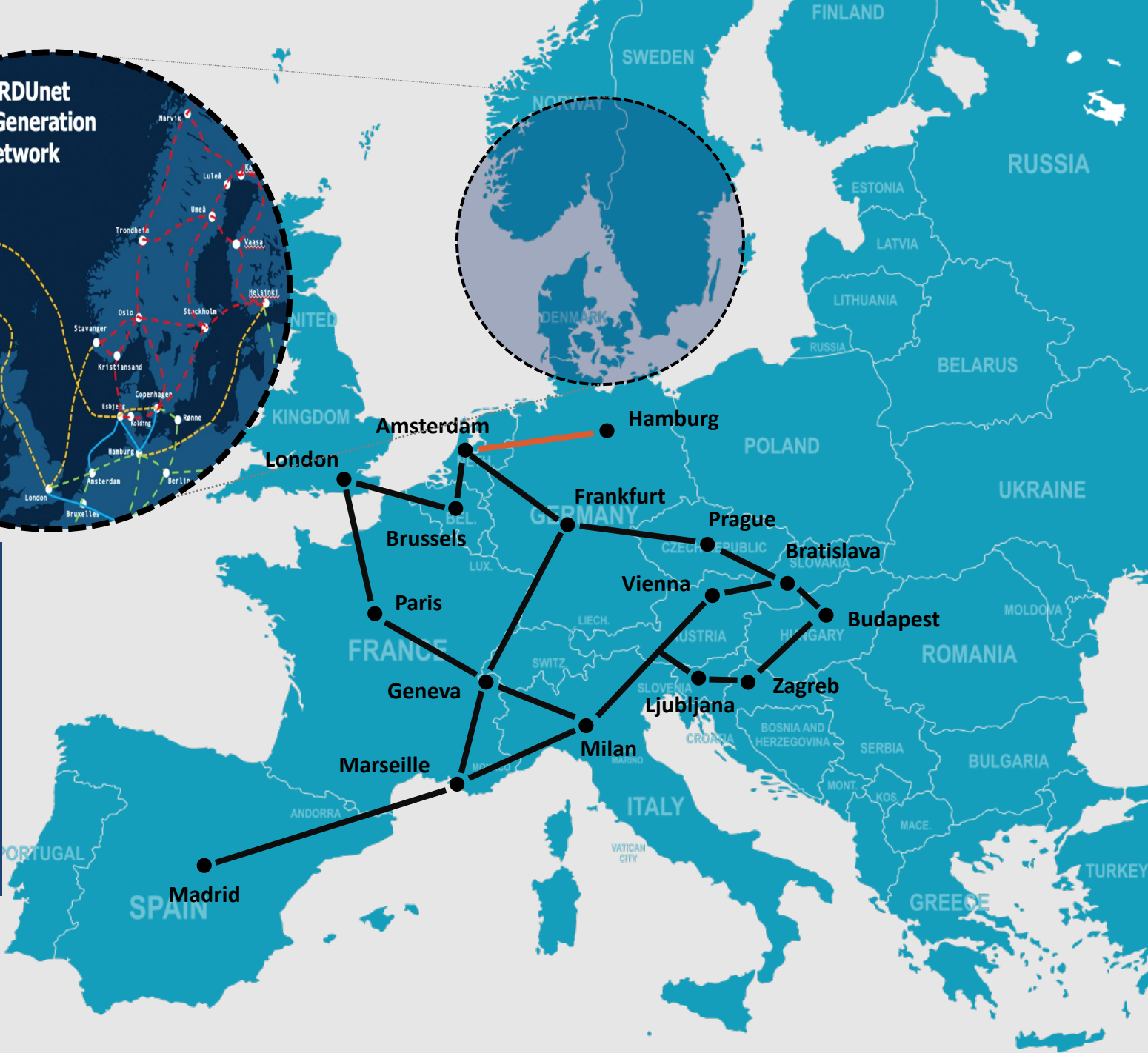
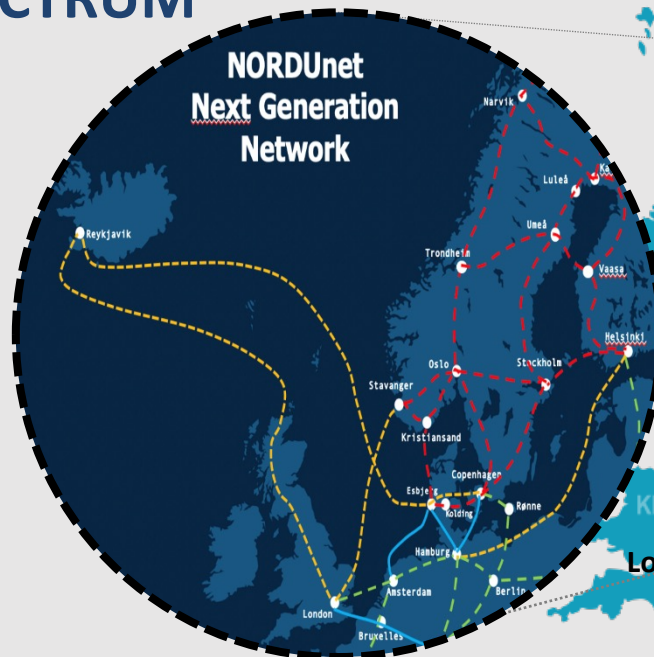
Infrastructure Project 1: GN4-3N (2019-2022/2023)

- ✓ Ensure that the GÉANT network is based on a **fibre footprint infrastructure** that is **guaranteed in the long term**, and that provides the basis for **excellent service to NREN partners, e-infrastructure projects, and the R&E community in general**
- ✓ **Bridge the digital divide** as far as transmission speeds and facilities are available, to all NRENs, within the budgetary limits defined by the project
- ✓ Monitor the **impact** of the extension of the GÉANT backbone and **make it financially sustainable**

Basically: build the long term ability to serve the most demanding users anywhere in Europe – together with the NRENs

GN4-3N: FIBRE AND SPECTRUM

FIBRE INFRASTRUCTURE AT START OF GN4-3N (2019)



Fibre Network at start of project
14 countries (+NORDUnet) on fibre
Short term contracts => higher maintenance costs, to be replaced
Other countries on (typically high cost) leased lines

	
Commercial Dark Fibre	NREN Spectrum

GN4-3N: INITIAL AMBITION: REFERENCE NETWORK IN GN4-3N PROPOSAL

Estimated investment cost for this network: 48 M€

24 countries integrated in this infra

Other partners – depending on budget:

Additional dark fibre (DF) /spectrum projects
or

Standard leased capacity (minimally 10GE,
might be 100GE by end of project)

Commercial
Dark Fibre

NREN
Spectrum

Long-term, high-
capacity leased lines



GN4-3N: CURRENT EXPECTATION (END OF 2023)

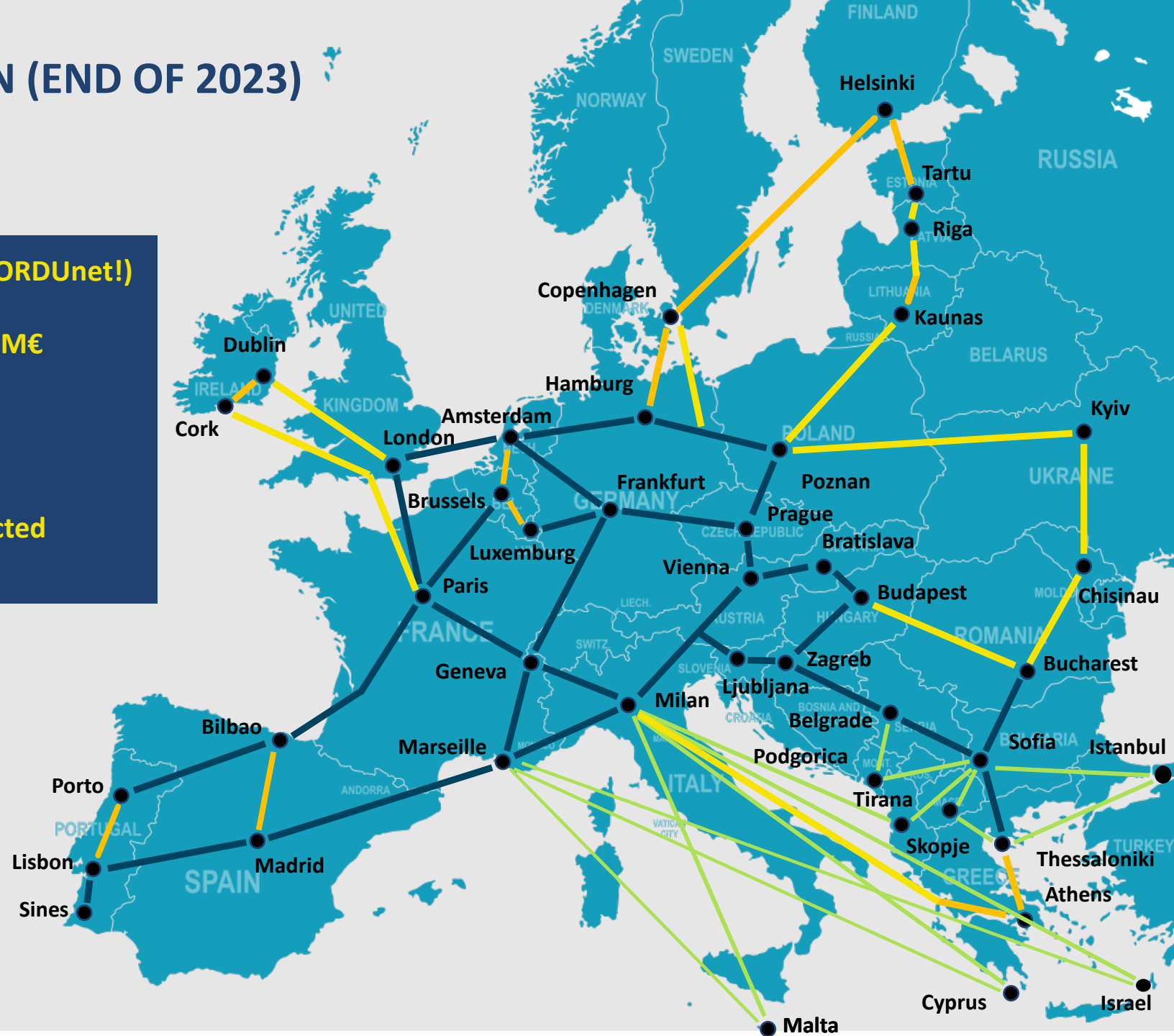
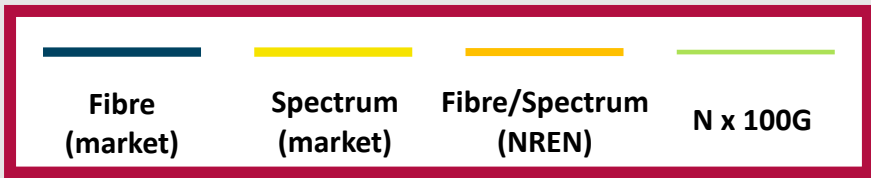
30 countries integrated in this infra (and add NORDUnet!)

Estimated investment cost for this network: 49 M€

Infrastructure ensured for 15 to 21 years

Considerable NREN contributions

Spectrum more accessible/available than expected



Status optical network 1st of March 2023

**27**

Countries connected
to GN4-3N network
(includes new 100G leased services)

**243**

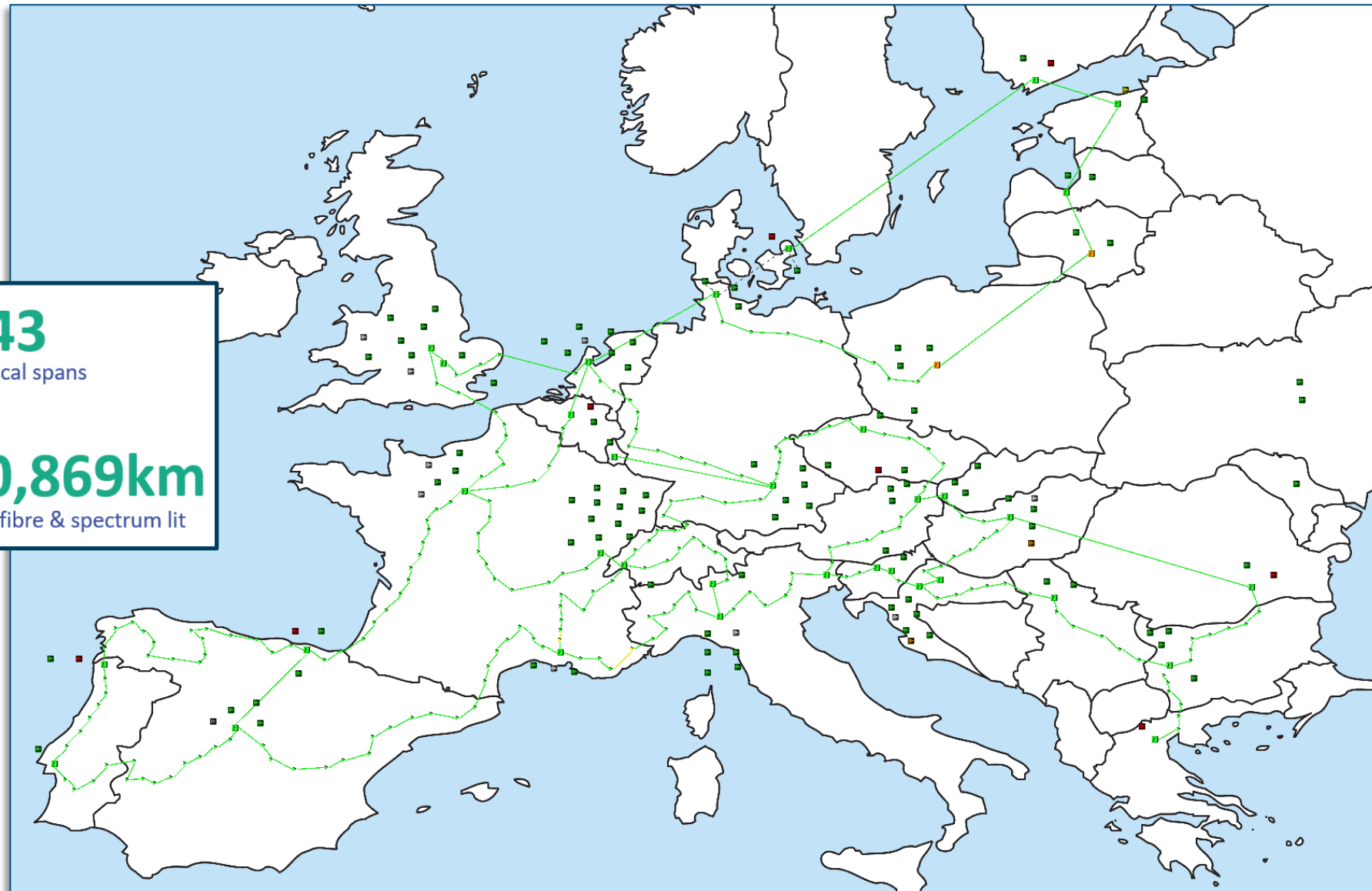
Physical spans

**368**

New Infinera nodes

**20,869km**

Dark fibre & spectrum lit



Infrastructure Project2: EaPConnect (<https://eapconnect.eu/>)



RENAM: Moldova



GRENA: Georgia



URAN: Ukraine



AZSciencenet: Azerbaijan



Asnet-AM: Armenia

CONNECT

INTEGRATE

STRENGTHEN

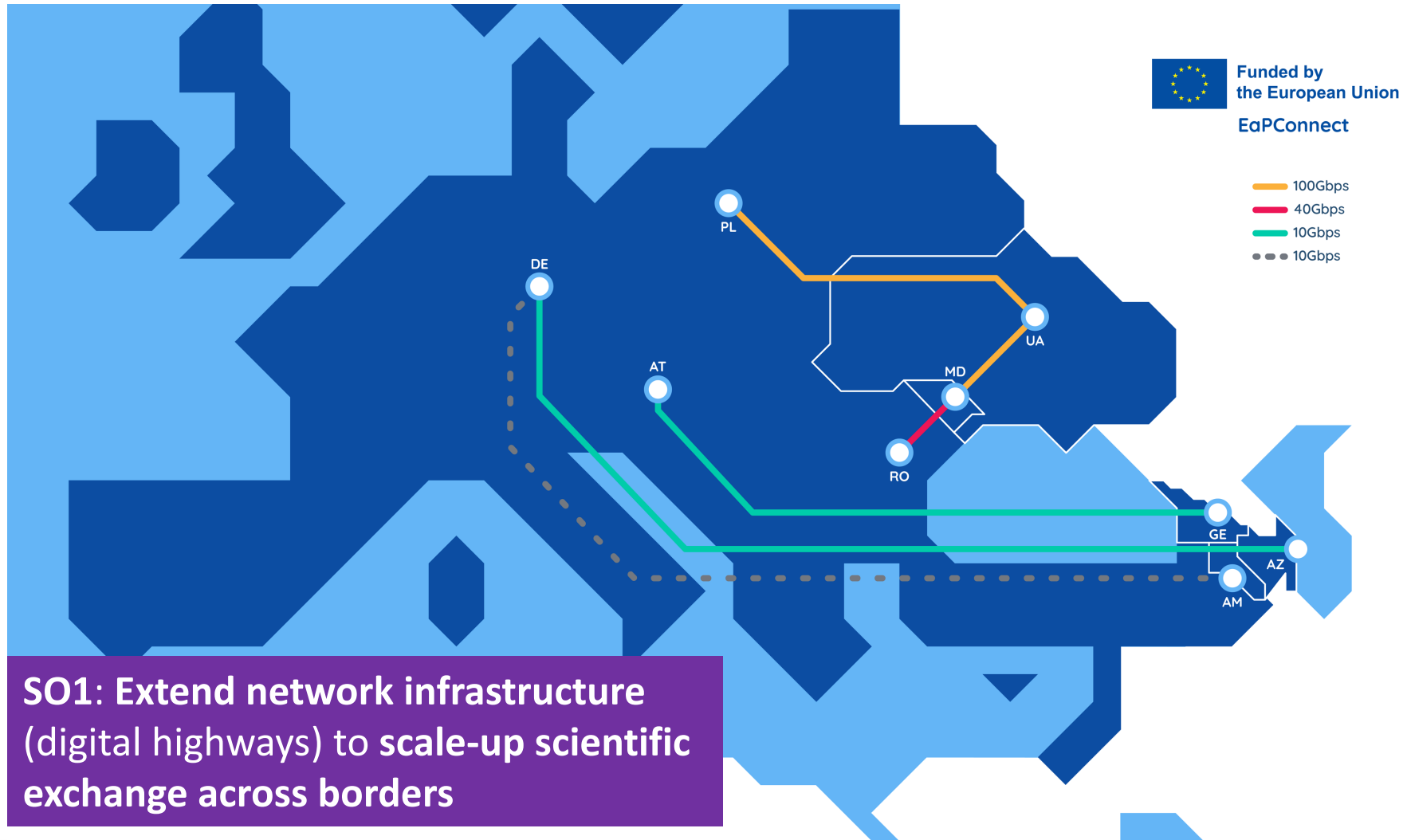
SO1: Extend network infrastructure (digital highways) to scale-up scientific exchange across borders

SO2: Increase the use of services implemented under EaPConnect and offer new services to enhance international cooperation in R&E.

SO3: Strengthen EaP NRENs' position in the national R&E ecosystems

**1st Phase: 2015-2021
2nd Phase: 2020-2025
Total funding: 24.5 M€**

Infrastructure Project2: EaPConnect (<https://eapconnect.eu/>)



Project 3: GN5-1 (2023-2024): Network Technology and Services

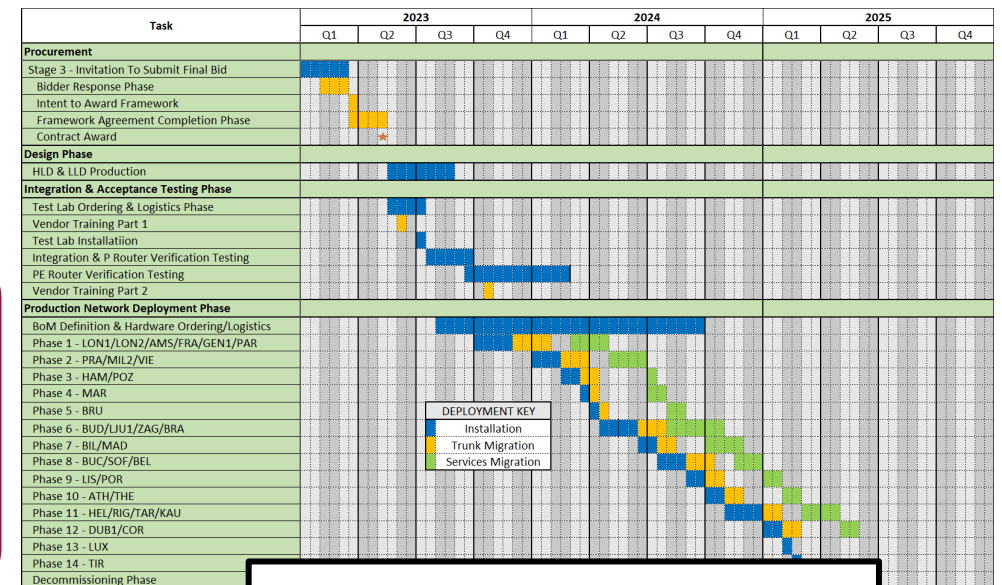
Building on the fibre and spectrum infra

Main Infra: Router Renewal: 2023-2025

- GÉANT IP Layer _needs_ renewal
- Ready for the future: 400G/800G/beyond
- ***Patience! Procurement to conclude in < 2 months***

Optical Based Services

- **Spectrum:** capabilities and services
- **400G and beyond:** technology – pluggables?



OPTIMISTIC DRAFT PLANNING

Dedicated IRU on dark fibre: enormous amount of capacity, long term.

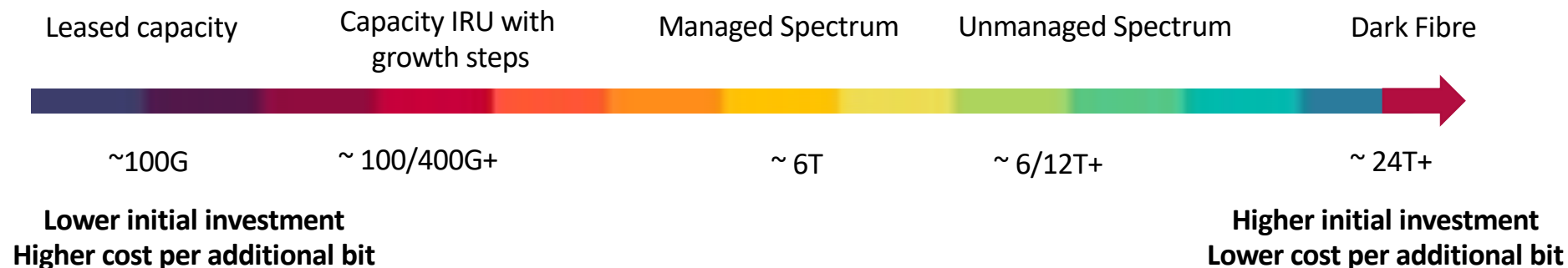
Spectrum: long-term investment *without the high cost of a full dark fibre pair*

Both allow for upgrades in line with technology evolution, at marginal cost, under own control

Network providers are now offering IRUs for spectrum – used in GÉANT network

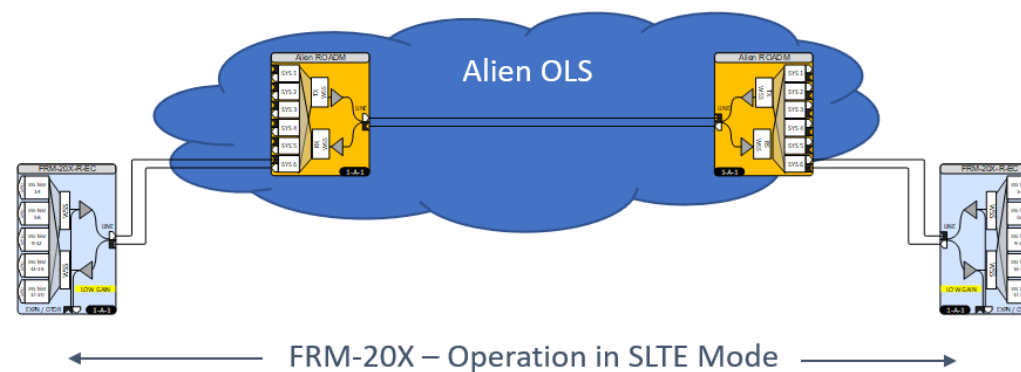
GÉANT will offer spectrum on its own fibres

NOTE: single wavelength still a/the workhorse for services – operational ease, and perfectly fine cost

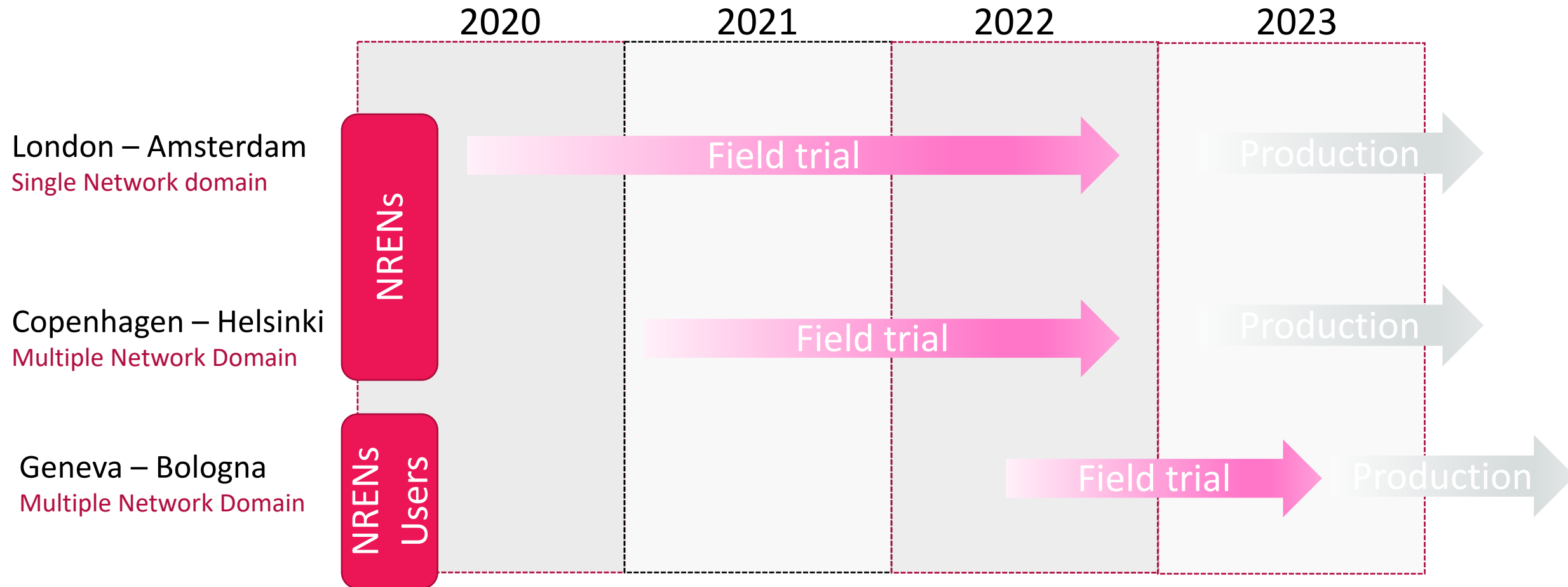


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- Extended C-Band has 4.8THz of spectrum, but this is typically not fully utilized
- Open Line Systems with FlexGrid allows spectrum to be managed in slices (6.25GHz)
- Each slice of spectrum can be 'owned' and operated by a separate network provider



- GÉANT uses the FlexILS, this is a flexgrid ROADM from Infinera
- System designed to be Open Line to support 3rd party transponders => 400/800G
- Flexible Add Drop of scalable slice of spectrum => Spectrum service



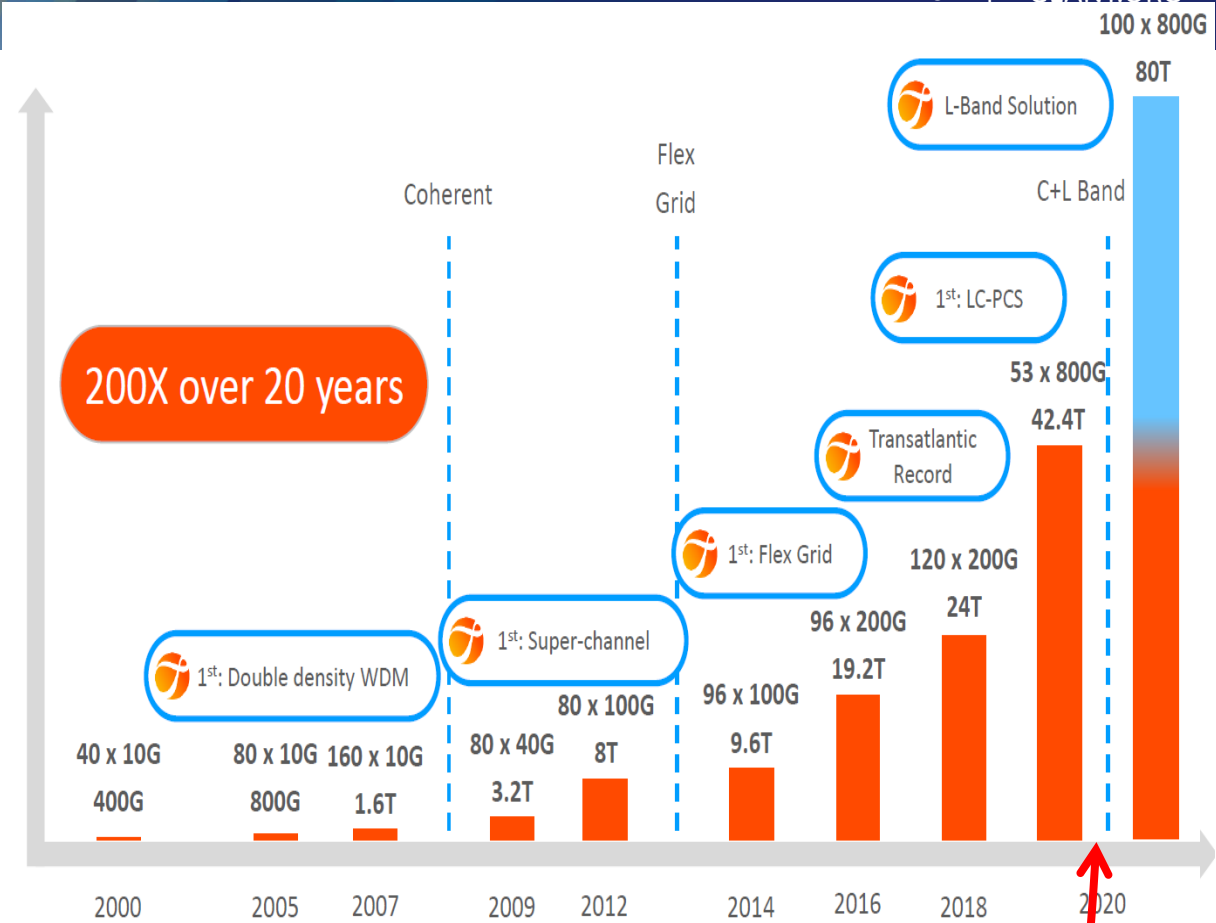
- **Optics capabilities** keep increasing fibre capacity
- DCI and pluggable form factors are current trend
- Up to 80Tbps on a fibre pair



Infinera Groove

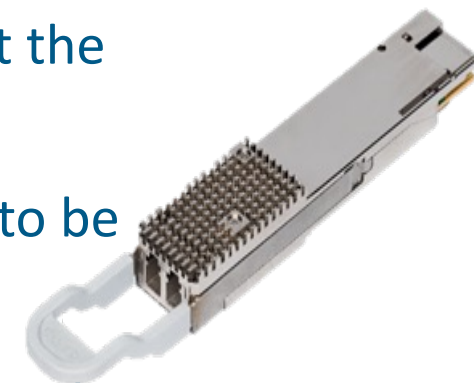


400 ZR Pluggable



Field Trial 2021:
800G Direct Detect
800G per λ , 42T per fiber

- The responses to the IP/MPLS procurement will affect the type of optics we use
- The capability of the new packet equipment to support ZR+ optics will affect the way we procure optics in the future
- The reach for ZR+ optics on real-world fibre with good margins is expected to be around **750km with 400G**
- The price of ZR+ 0dBm optics is expected to be in the range of 8k, resulting up to 50% cost reduction over CHM2T



Specification	Data rate	Modulation	FEC/coding gain	Target reach (fibre dependent)
OIF 400ZR	400G	DP-16QAM	OFEC/11.6dB	120km
OpenZR+	400G	DP-16QAM	OFEC/11.6dB	1400km
	300G	DP-8QAM	OFEC/11.6dB	2500km
	200G	DP-QPSK	OFEC/11.6dB	3000km
	100G	DP-QPSK	OFEC/11.6dB	8000km

Table: Max reach of ZR and ZR+ optics from Open ZR+ MSA

Guy Roberts' blog: <https://connect.geant.org/2022/12/19/are-400g-zr-and-400g-xr-ready-for-geants-ip-backbone>

- Most routes in GEANT are suitable for ZR+ 0dBm
- Green routes are highly suitable
- Yellow routes are possible, but may be spectral density issues

Route	fibre length (km)		Route	fibre length (km)		Route	fibre length (km)
AMS-FRA	672		BIL-PAR	1,120		LJU-LJU	4
AMS-LON1	476		BIL-POR	1,067		UDI-LJU	176
FRA-GEN1	831		LIS-POR	366		RIG-SIA	150
FRA-PRA	668		LIS-MAD	897		ZAG1-ZAG2	10
GEN1-GEN2	5		HAM-POZ	692		BEL1-BEL2	27
GEN1-MIL1	714		POZ-PRA	748		BUC-SOF	611
GEN2-MAR	700		BRA-BUD	249		PAR-BRU	524
GEN2-PAR	788		BRA-VIE	111		LIS-SUN	172
LON1-LON2	70		BUD-ZAG	456			
LON2-PAR	626		LJU-MIL1	678			
MAD-MAR	1,400		LJU-ZAG	197			
MAR-MIL2	770		BEL-SOF	458			
MIL1-MIL2	23		BEL-ZAG	546			
MIL2-VIE	1,080		SOF-THES	512			
PRA-VIE	451		DUB1-DUB2	24			

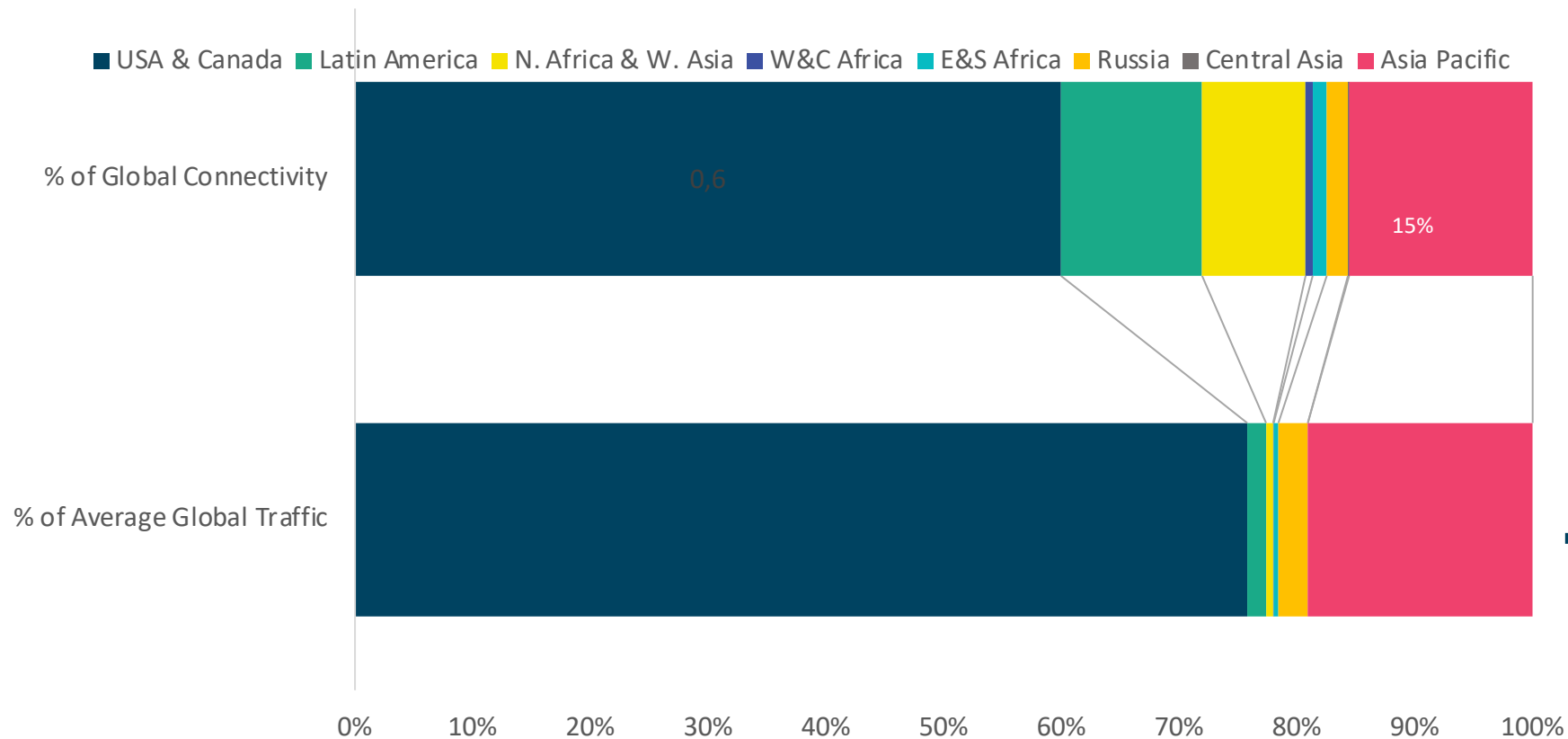
Many fibers good to go
**ALTERNATIVE WITH DCI
 STILL EXISTS**

- CIM8: Coherent Interconnect Module 8: 1.2T pluggable coherent solution
 - Available now from Acacia, not clear what equipment provider take up will be – first in DCI equipment
 - Probabilistic shaping (and Nyquist carriers?)
-
- 800G ZR+ is in the process of being standardized
 - Form factor unknown, but target of compatibility with 400G ZR+ is being targeted
 - 400G XR optics are similar performance to ZR+, but with multipoint capabilities



Guy Roberts' blog: <https://connect.geant.org/2022/12/19/are-400g-zr-and-400g-xr-ready-for-geants-ip-backbone>

Global Challenge: GÉANT's regional distribution of Global Connectivity and Global Traffic (@31 Dec 22)



GÉANT's Intercontinental Traffic:

- 75% North America
- 19% Asia-Pacific region

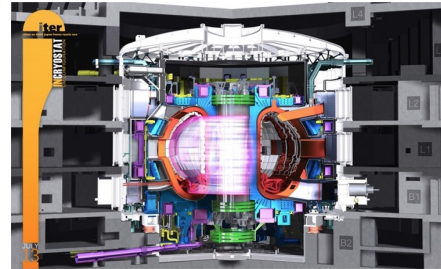
Global traffic forecast – driven by big data movers

LHC

- 200 sites across the globe
- 50% of GÉANT global traffic
- High Luminosity HLC from 2029



Map courtesy of Google.com



ITER – Fusion Research

- Several PBs of data per year
- To be copied from France to multiple locations globally

Astronomy



- Square Kilometre Array
 - Detectors in 100 Gbps capacities required
- Chile:
 - Cherenkov Telescope Array
 - ESO – Very Large Telescope

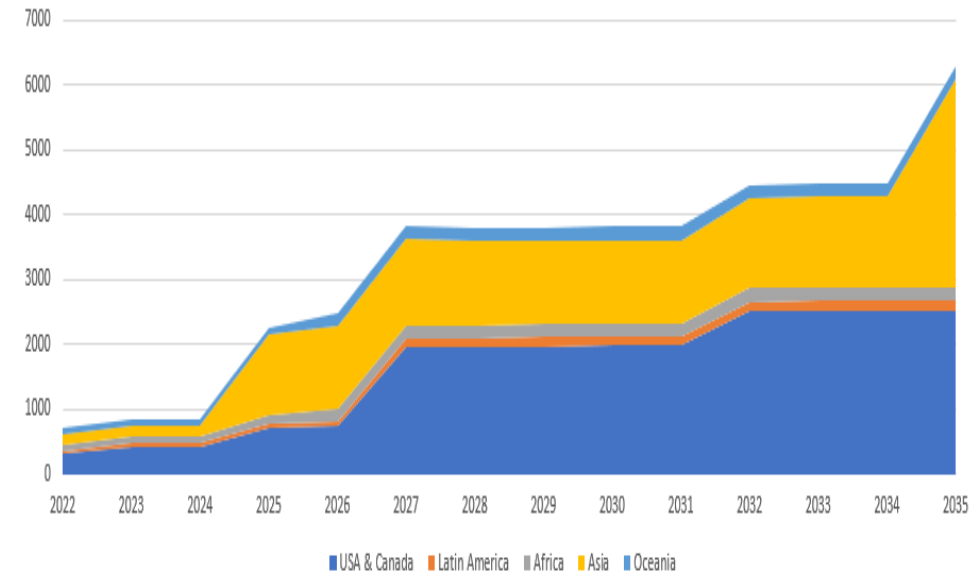


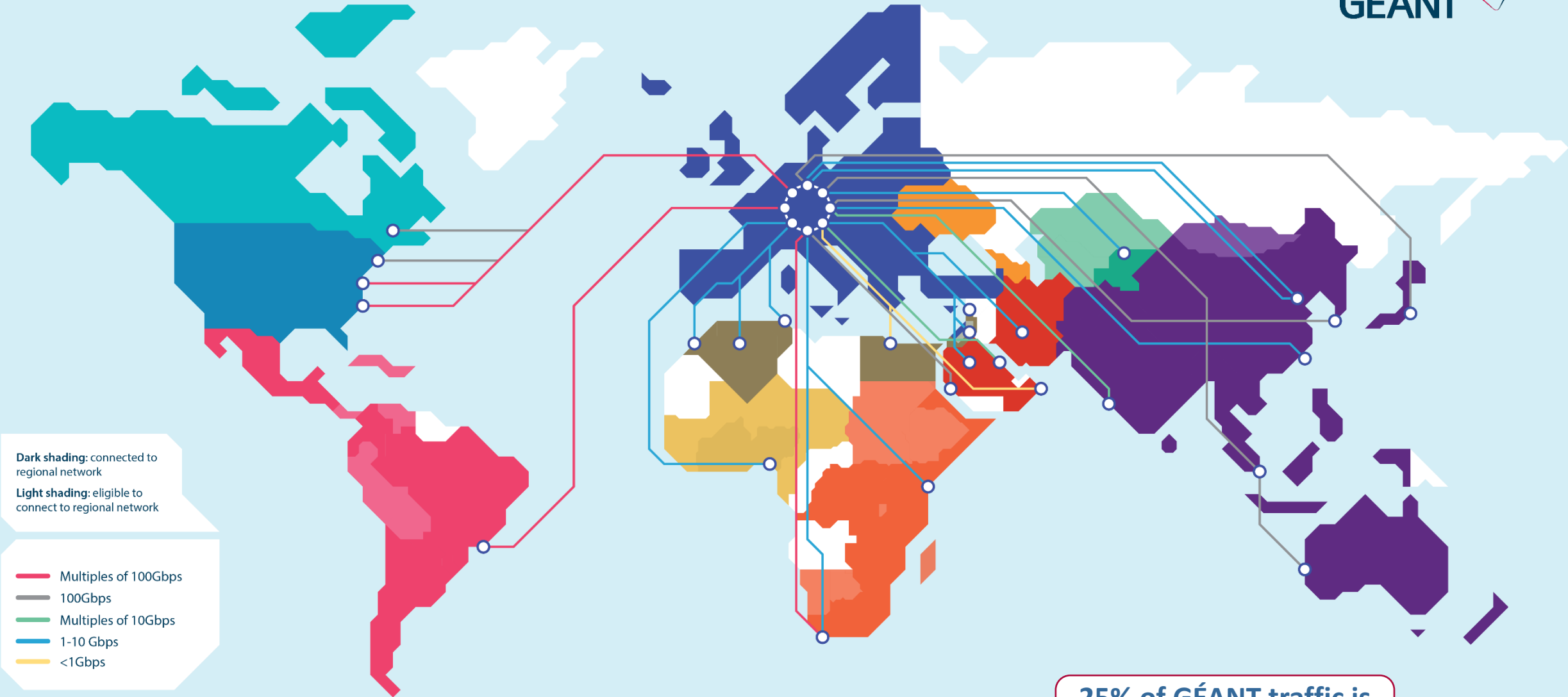
Earth Observation

- Distributing Copernicus data worldwide

Estimated annual growth at 35%

Global Traffic Forecast 2022-35 (Gbps)





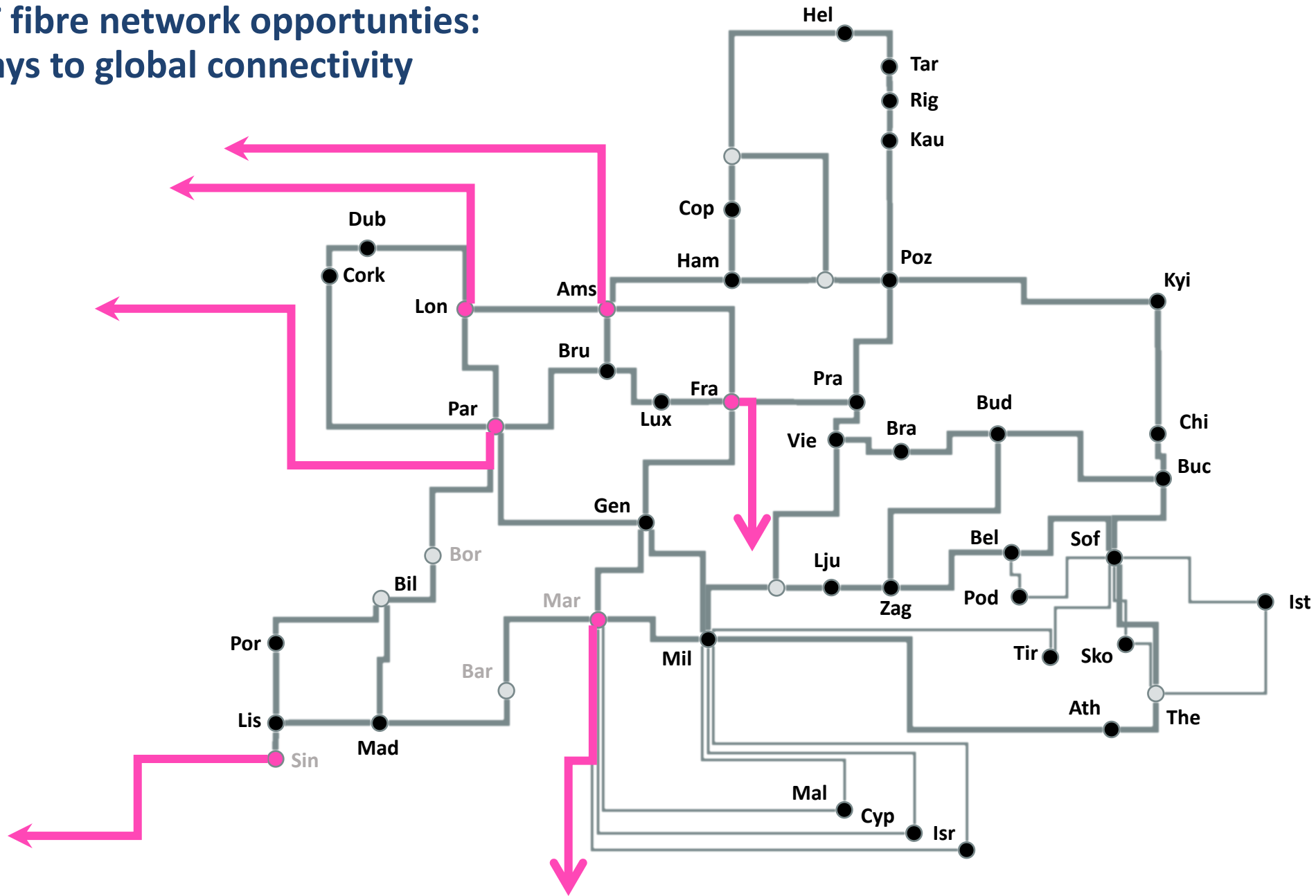
Dark shading: connected to regional network
Light shading: eligible to connect to regional network

- Multiples of 100Gbps
- 100Gbps
- Multiples of 10Gbps
- 1-10 Gbps
- <1Gbps

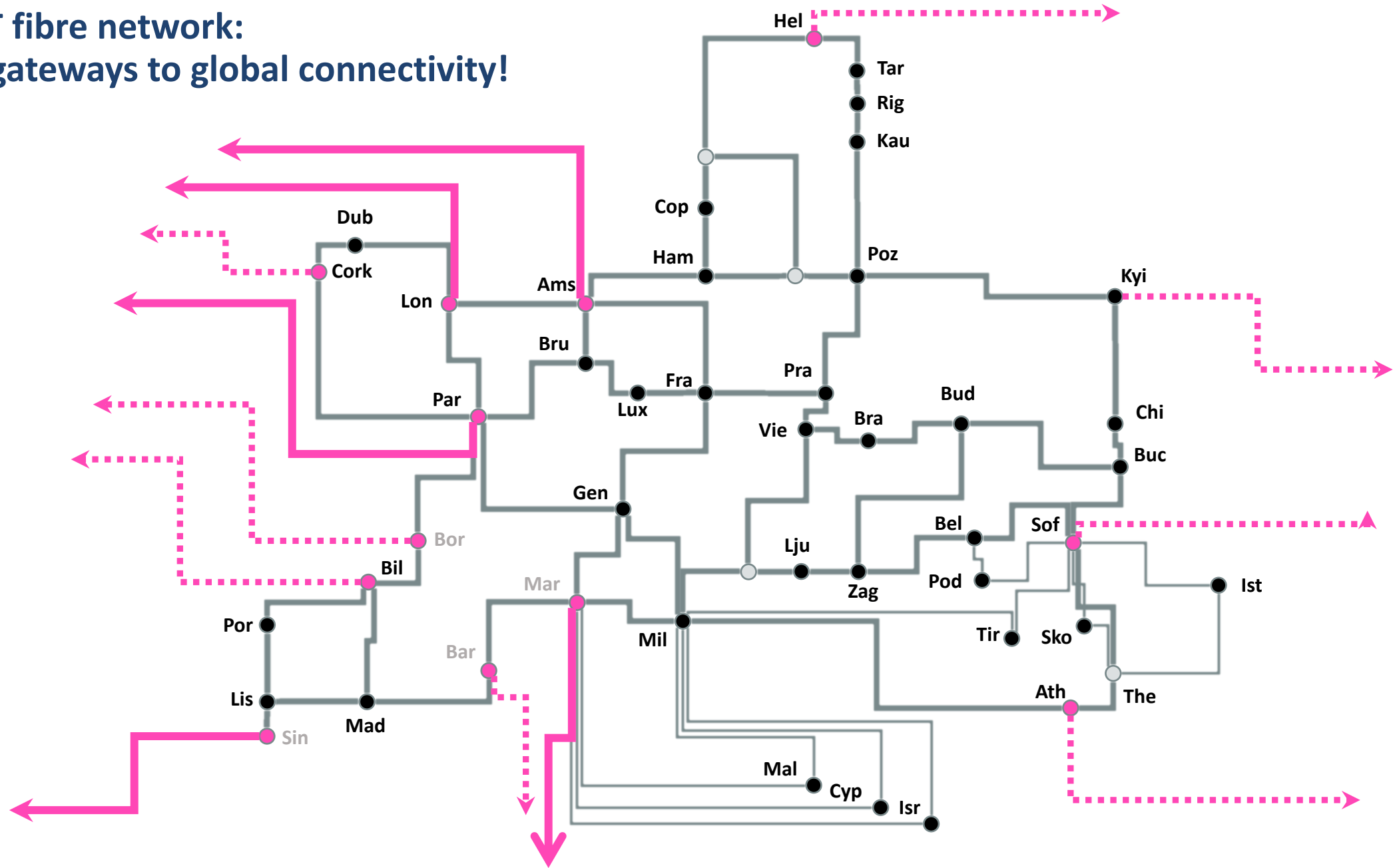
~ 1.9 Tbps

25% of GÉANT traffic is intercontinental

GEANT fibre network opportunities: gateways to global connectivity



GEANT fibre network: More gateways to global connectivity!



Meeting the needs – investments and partnerships

Collaborative approach with R&E networking organisations



Harness new funding streams & infrastructure opportunities

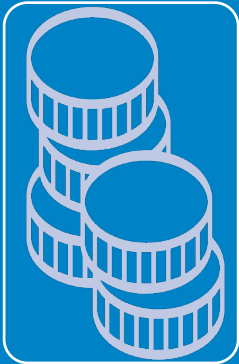


Intercontinental Connectivity – GN5-IC1



EC's flagship infrastructure investment programme (2021-27) – to “connect Europe to the world”

GN5-IC1 – renewing and expanding GÉANT’s intercontinental connectivity



First dedicated EU-funded project for intercontinental connectivity

Part of 7-year GN5 FPA under Horizon Europe

€15M – 3 years (start 1 Dec 2022)



OBJECTIVES

1) **Deliver long-term connectivity to at least 2 continents** (min 7 years)

2) **Long-term planning** for future activities

IC1 immediate investment focus

Asia-Pacific

- 100Gbps leased link from Marseilles to Singapore
- 7-years IRU (option of 3-year extension)
- RFS March/April 2023
- Peering with CSTnet at SOE

North Atlantic

- Upgrade to Terabit capacity - preferably via spectrum solution
- Market engagement underway – implementation Q1/2 2024

EU Global Gateways: harnessing new infrastructure opportunities

EC's flagship strategy to invest in infrastructure across the world
(€300bn 2021-27)
to "connect Europe to the world"



Digital sector:

Investment in submarine & terrestrial fibre-optic cables

"Team Europe" approach:
mobilising private sector investment
through EU grants and loans from EU
financial institutions (e.g. EIB)

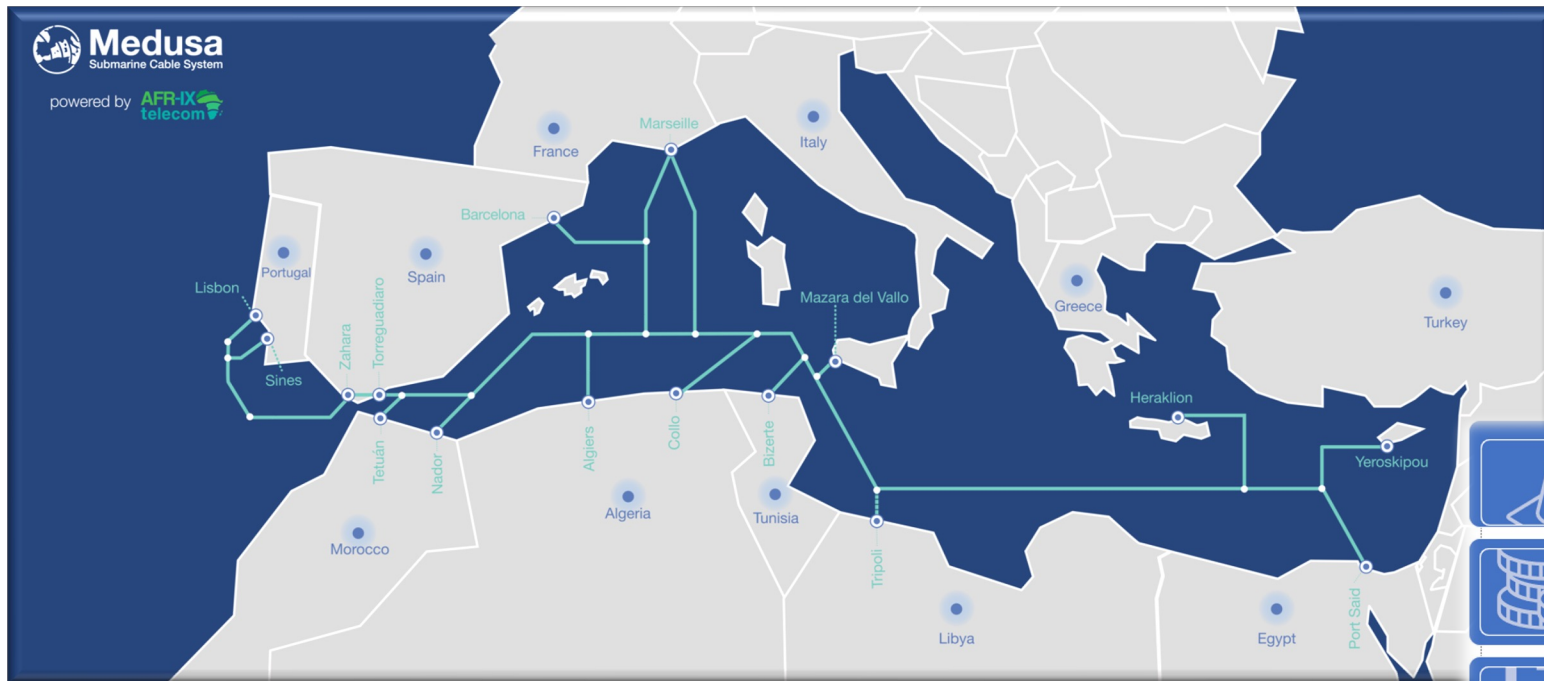
Priority data
gateways
(as per EC Communication
March 21)



- EU-Latin America
- EU-Mediterranean
- EU-Atlantic
- EU-North Sea & Arctic
- EU-Baltic-to-Black Sea



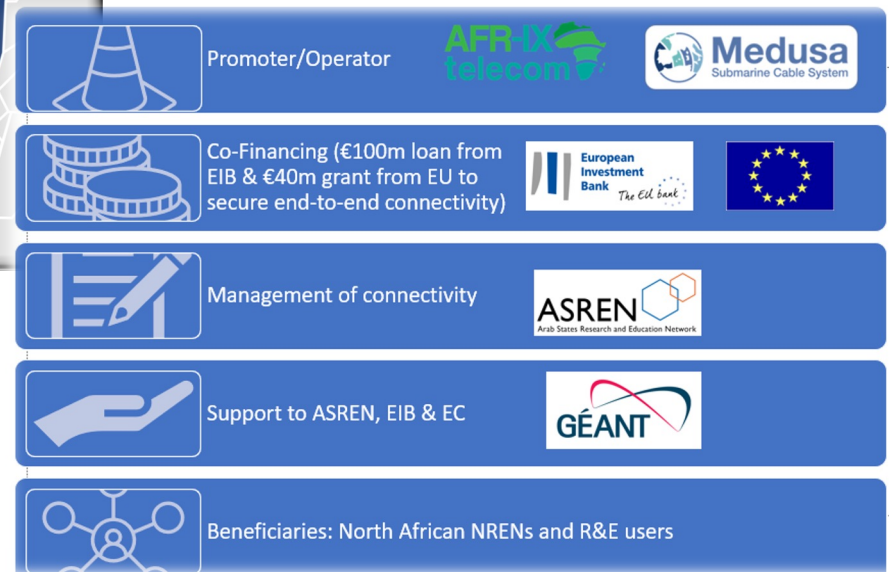
Medusa – the 1st EU Global Gateway project underway...EU-Mediterranean



€40M EU-funding
200Gbps end-to-end
international connectivity

Phased implementation:

- Morocco, Tunisia RFS: Q3 2024
- Algeria, Egypt RFS: Q2 2025



Concluding and summarising

- **GEANT is addressing long term challenges**
- **European Infrastructure has radically changed**
 - Fibre project nearly finished
 - Packet layer to follow soon
 - ⇒ Capacity and Capabilities on European footprint
- **International connectivity focus**
 - Long term investments in the next few years
 - ⇒ (Access to) Capacity and Capabilities on global scale



Thank You

Any questions?

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